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GRAIN SIZE CHART OF URANIUM

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GRAIN-SIZE CHART FOR URANIUM

INTRODUCTION

The metallurgist who is familiar with uranium is aware that the metallographic study of the metal has been complicated by certain factors. Of these factors, two, namely, the anisotropic crystal structure and the presence of the so-called beta "ghost" grains, have made accurate and rapid grain-size determinations, by comparison with existing grain-size charts for other metals, difficult at best.

With this in mind, an attempt has been made to devise a chart specifically for uranium. As the metal is observed metallographically by both polarized light and bright field illumination, all structures have been photographed using both methods of illumination. In the production of the desired grain diameters, the fabrications and heat treatments were made as nearly typical to those used in practice as was possible. The magnification used in photographing the structures was chosen because of its widespread use by those laboratories engaged in the metallographic study of the metal.

It is hoped that this grain-size chart will prove of some value to those metallurgists who are involved in the study of uranium.

EXPERIMENTAL PROCEDURE

I. Production of Desired Grain Sizes

To obtain a grain-size chart that contained a typical uranium structure for each desired grain size and also one which possessed sufficient spread of grain diameters with a proper division between grain sizes, it was necessary to actually produce the desired grain sizes.

The metal used for this work was Hanford uranium of average purity. All heat treatments were under vacuum with the exception of one specimen which was beta treated in a lead bath and quenched in water. The temperatures listed in the following paragraphs are within a tolerance of plus or minus 10°C.

To obtain the average grain diameters of 0.009 mm., 0.015 mm., and 0.020 mm., the uranium was rolled at 400°C. to a 1/2-inch round and heat treated as follows:

Grain Diameter Obtained	Heat Treatment
0.009 mm.	450°C. - 1 hr. - FC
0.015 mm.	550°C. - 2 hrs. - FC
0.020 mm.*	650°C. - 1/2 hr. - FC.

In order to produce the desired grain sizes above 0.02 mm., metal was cold worked varying amounts and annealed accordingly in the alpha region. Table I lists the amount of cold work and subsequent heat treatment used to produce particular grain sizes.

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* It was found that annealing this particular material for 360 hours at 600°C. did not appreciably increase the grain size of 0.020 mm.

TABLE I. METHODS OF OBTAINING DESIRED GRAIN SIZES

Grain Diameter Obtained, mm.	Amount of Cold work Reduction in Area, %	Annealing Temperature, °C.	Time Annealed, Hr.	Method of Cooling
0.033	50	600	1	Furnace
0.036	40	590	20	"
0.049	20	620	3	"
0.057	30	600	3/4	"
0.062	20	600	72	"
0.073	20	600	144	"
0.083	20	600	306	"
0.094(1)	20	600	306	"
0.105(2)	(2)	610	240	"
0.118(1)	20	600	306	"

(1) The areas shown for these grain diameters were chosen to give maximum grain size and not as typical areas in the specimen.

(2) This specimen was rolled at 400°C. to 1/2-inch round, beta treated in a lead bath at 700°C., water quenched, and then annealed as shown.

II. Method of Obtaining Grain Count

The average grain diameters listed in the chart were calculated by the Jeffries' method of grain-size determination as recommended by the American Society for Testing Materials. This method was applied directly to the photographic print. A total of three checks were made on each grain count, and all counts involving the smaller grain diameters were made with the aid of magnifying lenses.

III. Metallographic Technique

A. Grinding. All specimens were cut to the desired size for metallographic examination by a cut-off wheel operating under a water spray. The specimens were ground on rotary discs under a water spray with the following sequence of grinding papers:

240 grit

400 grit

600 grit.

B. Polishing. The ground specimens were polished electrolytically in a cell bath of the following composition:

50 c.c. Chromic acid base solution
(100 g. CrO_3 + 118 c.c. H_2O)

200c.c. Glacial acetic acid.

The cathode of the cell was stainless steel, while the specimen to be polished served as the anode. The current density at which the cell operated was 2-1/2 to 4 amp./sq. in. The bath temperature was held at 40°F. Total time of polish for each specimen was between 5 and 10 seconds.

The surface obtained by this method was used for polarized light examination.

C. Etching. For bright field examination, the polished surfaces were etched electrolytically. The cell bath used for this operation was of the following composition:

10 c.c. Chromic acid base solution
(100 g. CrO_3 + 100 c.c. H_2O)

180 c.c. Glacial acetic acid.

The operational temperature of this bath was not critical. A current density of 0.25 to 1.0 amp./sq.in. applied for 1 to 2 minutes was used to impart the etch.

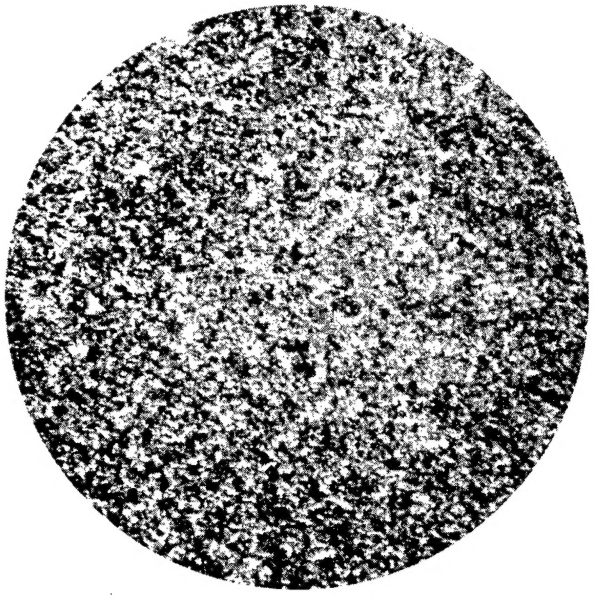
IV. Grain-Size Chart

The photomicrographs which are reproduced on the following pages are arranged in the order of increasing grain size. In all cases, the polarized light micrographs were exposed at that rotation of the specimen which resolved total grain population of the chosen field. All specimens photographed under bright field illumination were etched so that all grains could be observed with certainty.

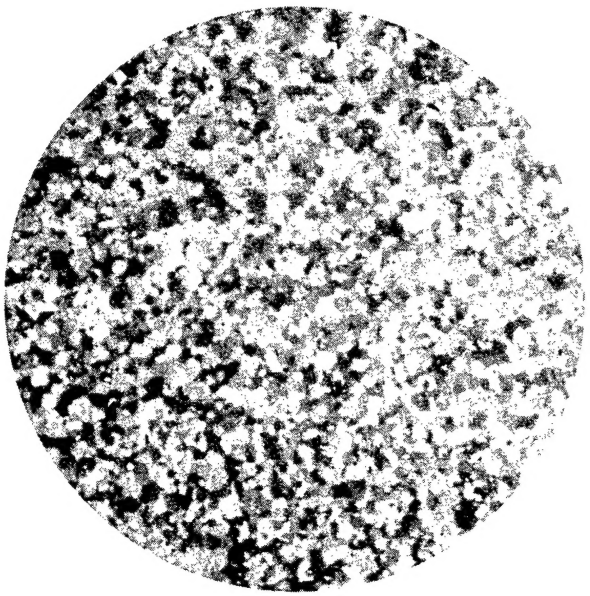
The following information is pertinent to the use of this grain-size chart:

1. Magnification - 100X
2. Area of circles - 5000 sq. mm.
3. Choice of field - polarized and bright field micrographs are not necessarily of identical fields.

POLARIZED LIGHT

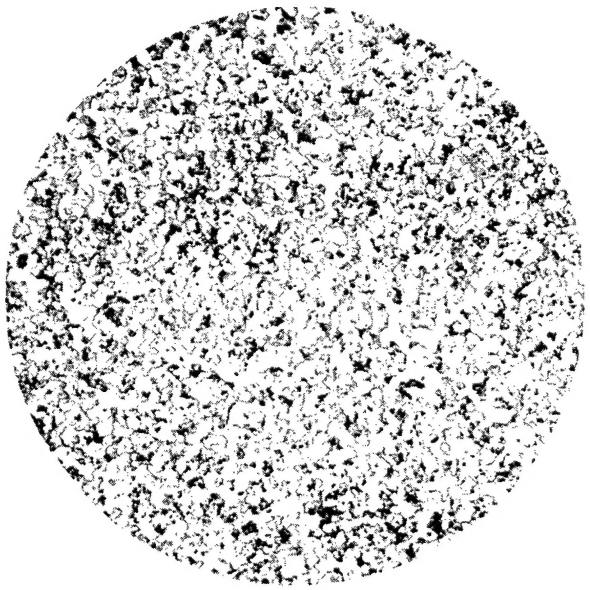


71138
AVERAGE GRAIN DIAMETER
0.009 mm



71190
AVERAGE GRAIN DIAMETER
0.015 mm

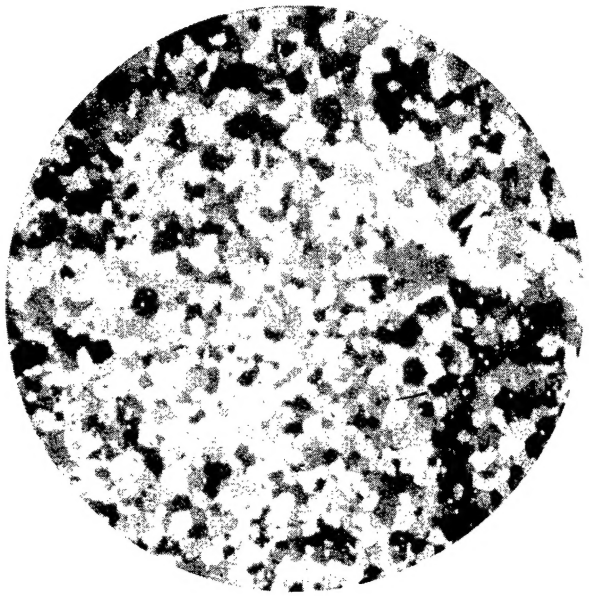
BRIGHT FIELD



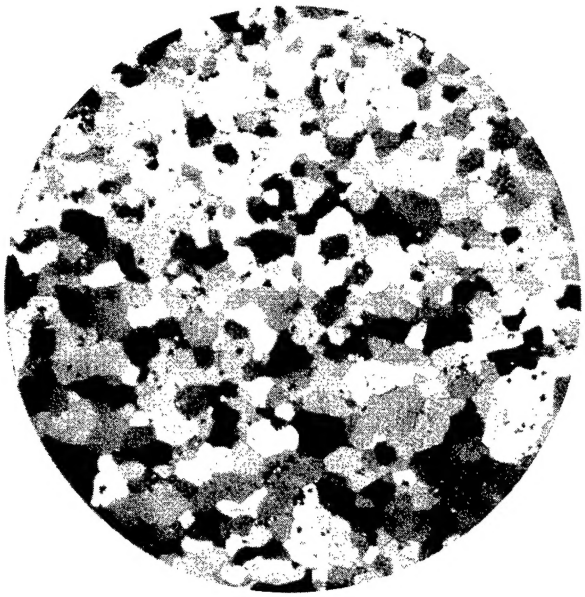
71191

GRAIN-SIZE CHART, URANIUM

POLARIZED LIGHT

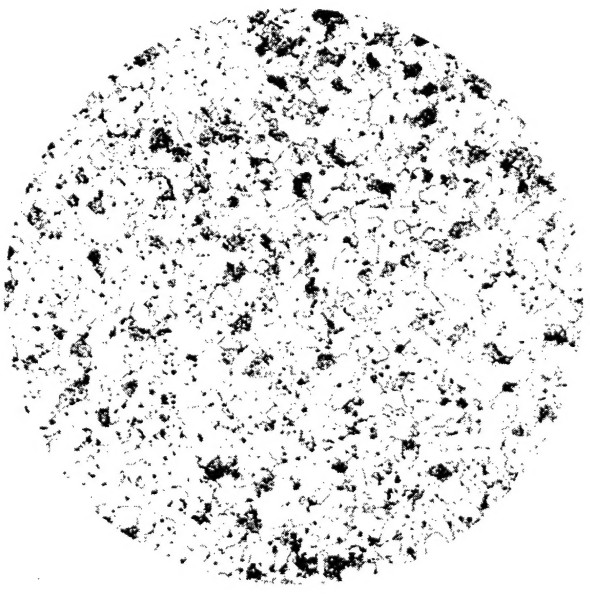


71196
AVERAGE GRAIN DIAMETER
0.020 mm

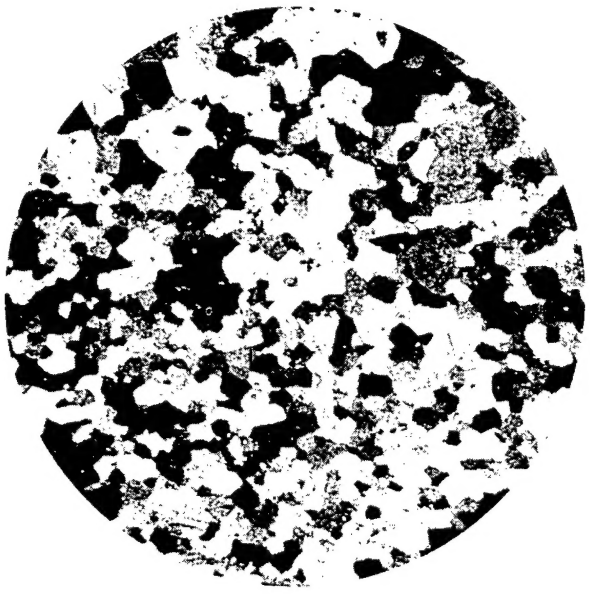


71204
AVERAGE GRAIN DIAMETER
0.033 mm

BRIGHT FIELD



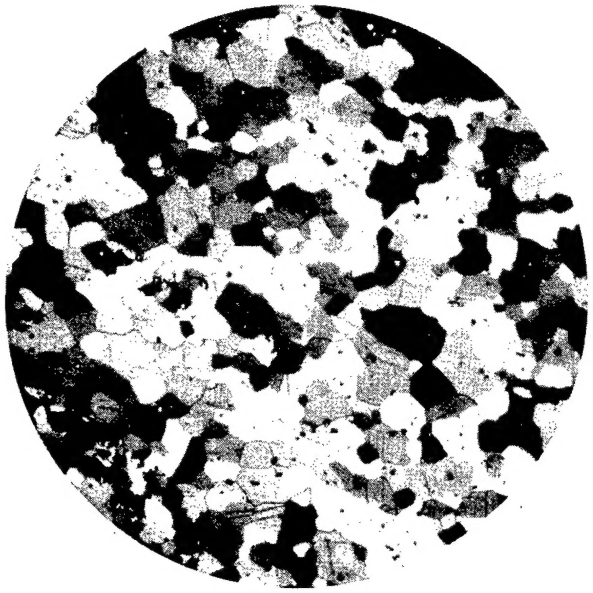
71197



71205

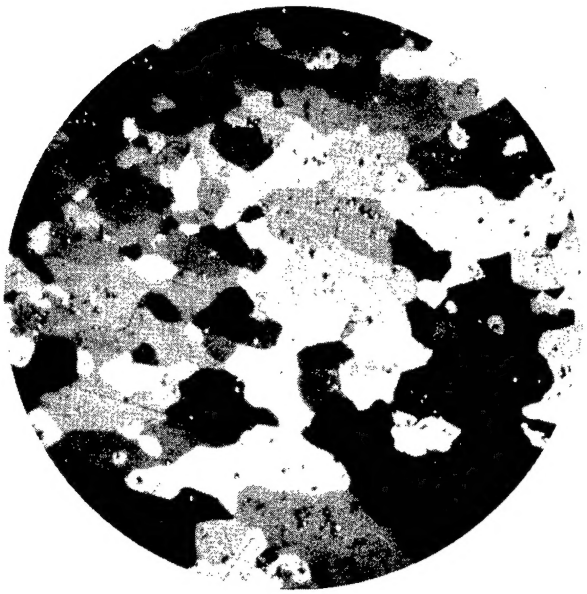
GRAIN-SIZE CHART, URANIUM (Continued)

POLARIZED LIGHT



71206

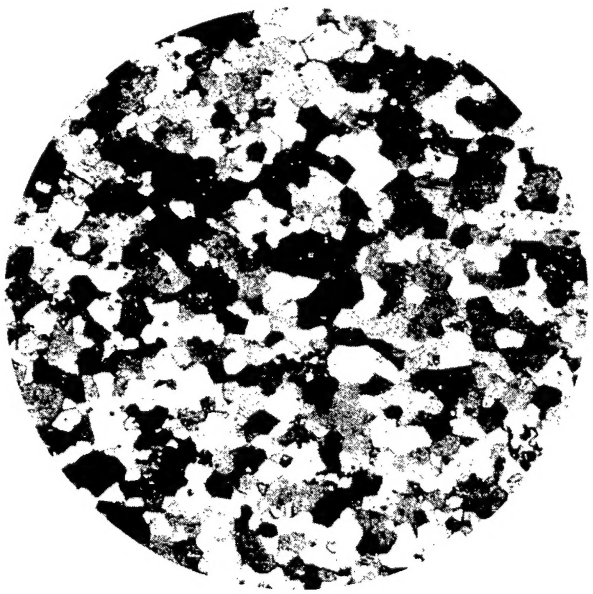
AVERAGE GRAIN DIAMETER
0.049 mm



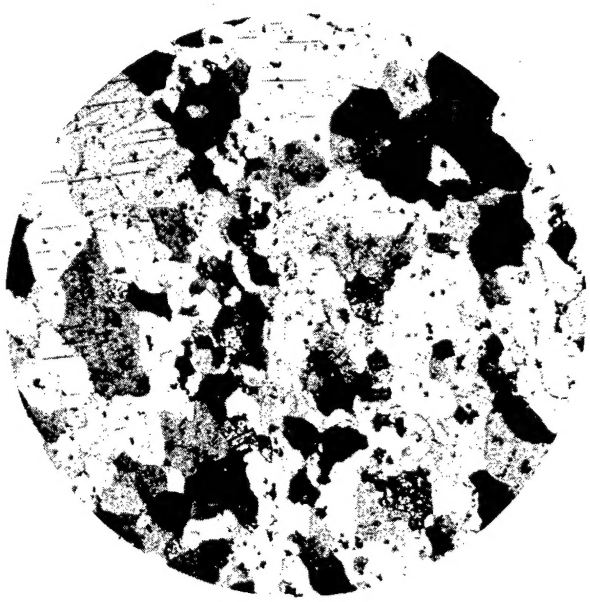
71208

AVERAGE GRAIN DIAMETER
0.057 mm

BRIGHT FIELD



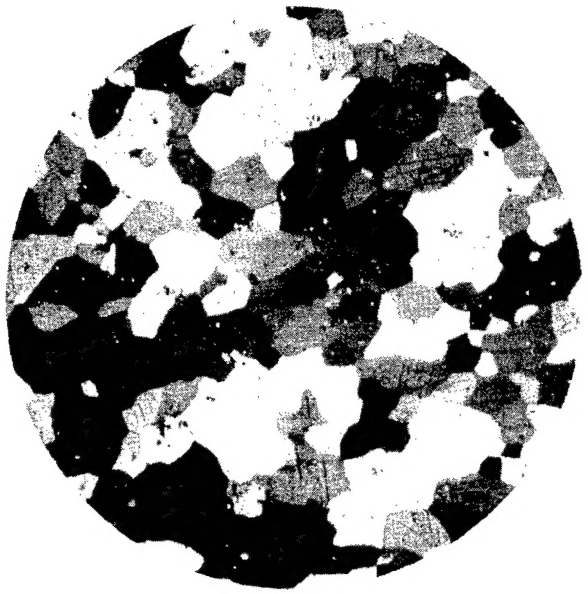
71207



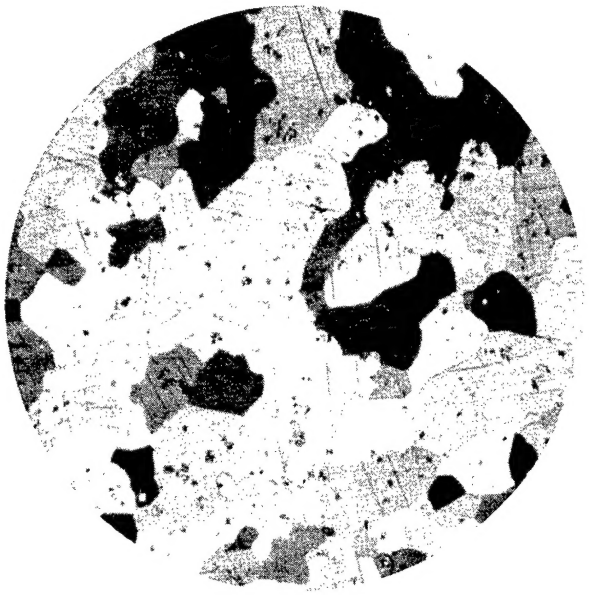
71209

GRAIN-SIZE CHART, URANIUM (Continued)

POLARIZED LIGHT

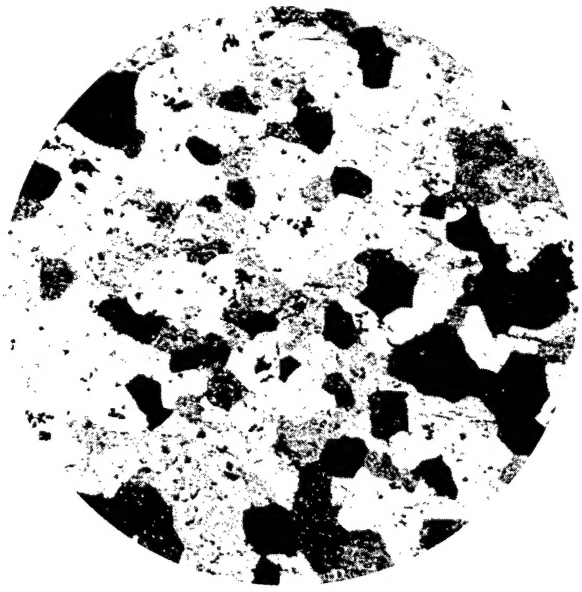


71227
AVERAGE GRAIN DIAMETER
0.062 mm

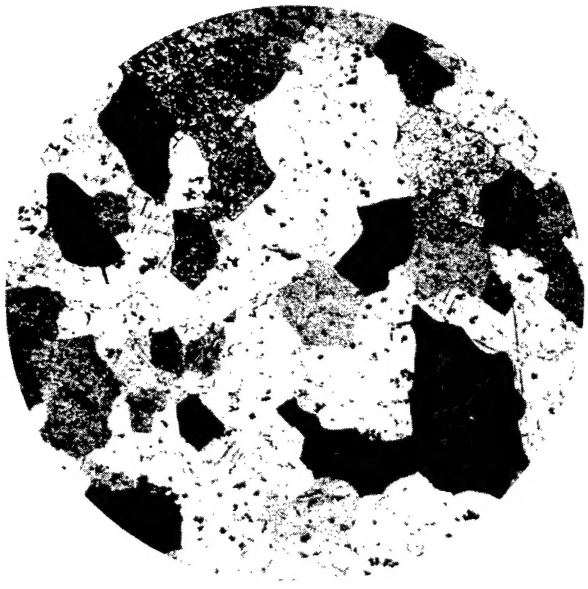


71229
AVERAGE GRAIN DIAMETER
0.073 mm

BRIGHT FIELD



71228

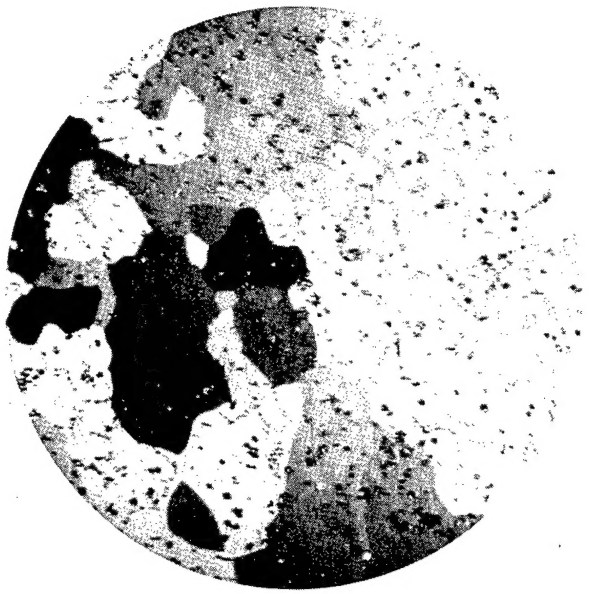


71230

GRAIN-SIZE CHART, URANIUM (Continued)

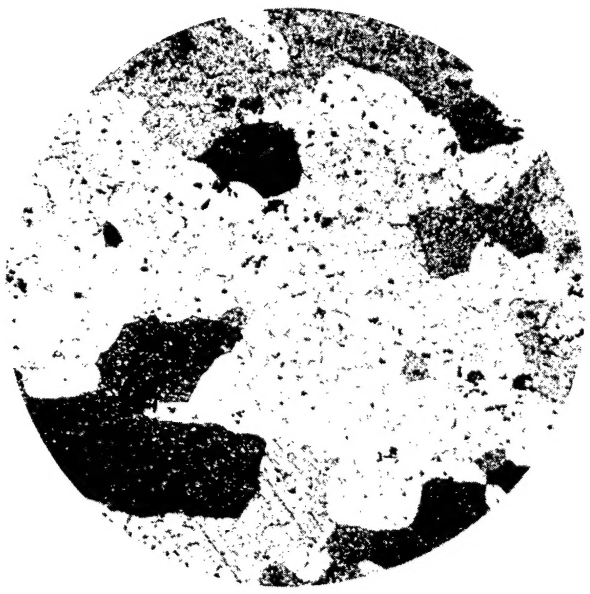
POLARIZED LIGHT

71231
AVERAGE GRAIN DIAMETER
0.083 mm

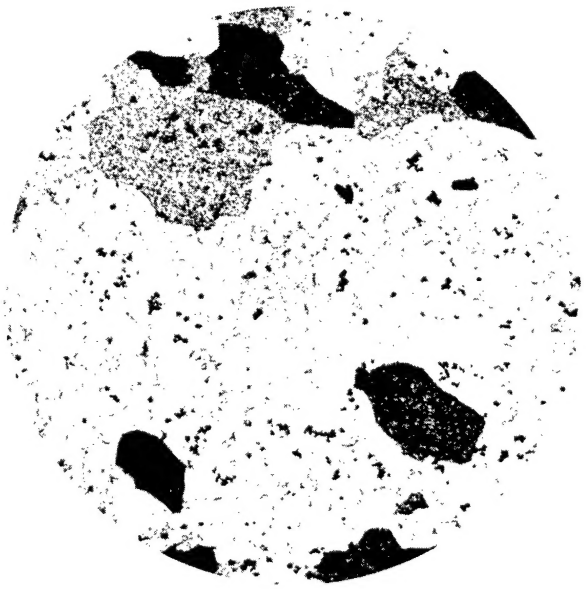


71233
AVERAGE GRAIN DIAMETER
0.094 mm

BRIGHT FIELD



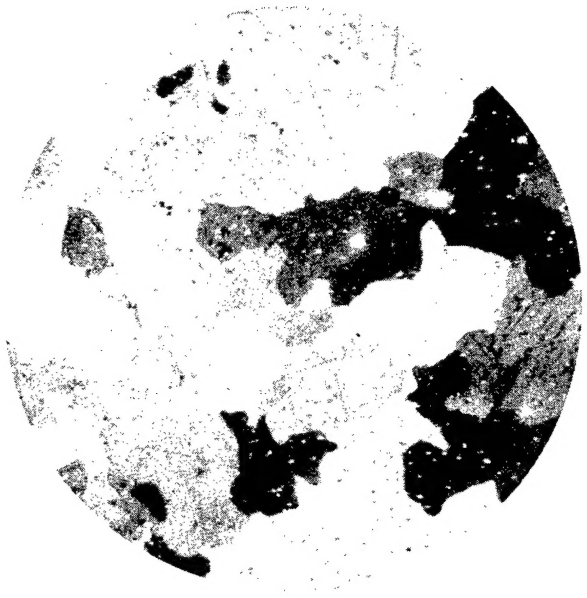
71232



71234

GRAIN-SIZE CHART, URANIUM (Continued)

POLARIZED LIGHT



71214

AVERAGE GRAIN DIAMETER

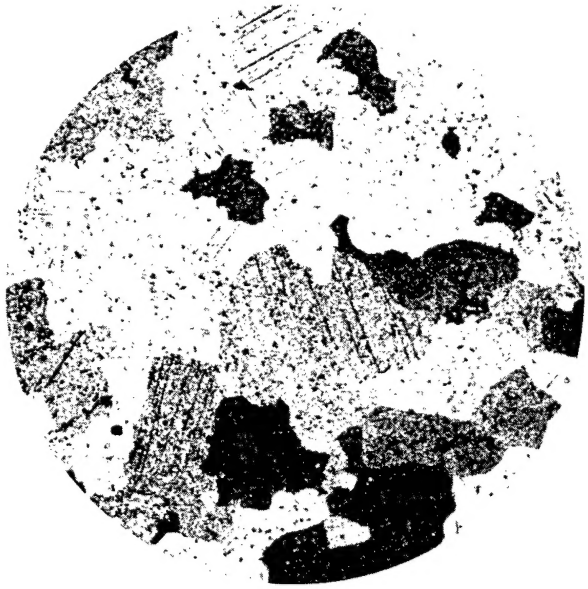
0.105 mm

71742

AVERAGE GRAIN DIAMETER

0.118 mm

BRIGHT FIELD



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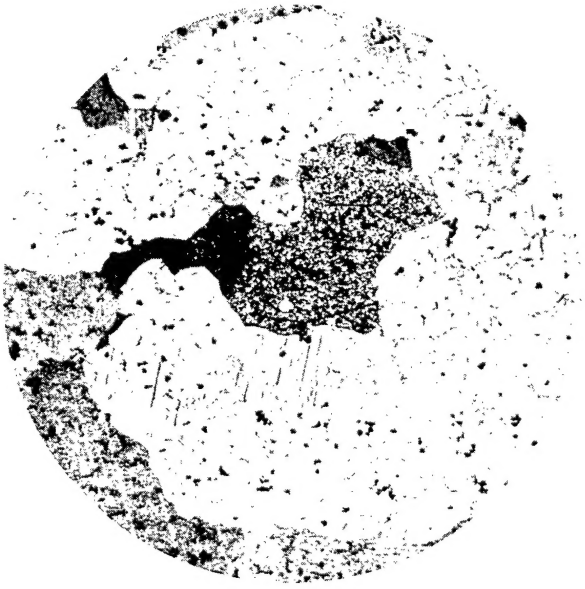

71743

GRAIN-SIZE CHART, URANIUM (Continued)

GPO 905377